Action Research on Flipped Robotics Instruction

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Abstract: Robotics and STEM (Science, Technology, Engineering, and Math) has become a growing field as technology continues to advance. Now, many schools have robotics programs to meet this interest in the hope of preparing and educating students with the knowledge and skills to not only participate and compete in robotics competitions but also to prepare them for future careers. There is a large interest in robotics among students and schools as it is a fun, engaging and hands on activity. Robotics however, does require a lot of time and resources, as students need to learn a variety of skills and information before they can apply their learning in designing, creating, programming and driving their robots. To better address the time and resources required for robotics I created a flipped instructional setting where students learn on their own prior to class from instructional modules and then review and apply their learning during in class activities. The purpose of this action research was to assess the effectiveness of a flipped classroom setting on the robotics team at a public school on Oahu. The effectiveness of this flipped classroom instruction was assessed through class observations as well as through assessing student work and progress. This paper examined the process that was used to develop this flipped classroom instruction.

Introduction

Robotics is an interdisciplinary study that integrates science, technology, engineering and math (STEM) into the designing, planning, creating, testing and improving of robots. Robots serve as an integral part of our society and can be found anywhere from factories to corporate industries and even in our own homes. This widespread distribution of robots that enables us to better our standard of living by making everyday tasks easier has gained much interest and popularity in recent years. It is now being used in schools to help prepare students with real world skills needed to create and problem solve.

Robotics in school is often an after-school activity or integrated further through elective classes, which focus on national or international robotics competitions. These competitions have specific time frames, rules and criteria challenging students to come up with solutions that will best solve the problem and then develop their robots accordingly. Since robotics involves the integration of STEM concepts to real world robotic creations it involves a lot of time and resources. These robotics competitions run on a set timeframe requiring specific deadlines, which limits the time that students have

to complete the robots. Students also often do not come with the knowledge base needed for them to independently create these complex robotic systems. As a result, instructor support and guidance is needed in order to create the best possible learning experience for the students. There is a need for this type of flipped classroom to better streamline student learning at a faster, more efficient and engaging way.

The purpose of this action research project was to assess the effectiveness of a flipped classroom setting on the robotics team at a public middle school on Oahu. This project created a flipped classroom setting to improve the robotics program, streamline instruction, and better utilize time, furthering student engagement. As a result, the goal was to help not only the school and the robotics team but also the students as they learn more about STEM and further their technical skills as they prepare for high school and their futures. It is imperative that we prepare the students for the future and that we allow them opportunities to further their learning in topics that they connect with and that interest them.

My role in this project was to facilitate the flipped classroom as the teacher ensuring that the students were learning and following the curriculum and instructions set up. As a result I oversaw and worked directly with the students in the class as they worked on their robotics projects. During the in-class portion I monitored and worked with students to give them feedback and specific instructions. Throughout both the instructional modules and the in-class activities I assessed both student learning as well as the effectiveness of this flipped instruction on the robot and for the students.

Literature Review

Robotics is a tool that introduces students to STEM concepts in a fun and interactive way. Robotics also enables students to work on teamwork, design and critical thinking skills, motivating them to problem solve and further their knowledge in this field (Malec, 2001). Students will therefore be able to gain hands on experience and integrate what they learn to real world tangible projects, which supports the Constructivist Theory (Fosnot and Perry, 2005). These projects and hands on creations allow students to express their creativity and innovation. The Constructionist Theory based on the work of Piaget and Papert focuses on this student centered, project based learning (Alimisis and Kynigos, 2009). By working with their team on the robot the students will be able to learn about different science, math and engineering concepts as well as teamwork, collaboration and other social skills. They will be able to apply what they learned in their core classes to their robotics projects and likewise use their hands on experience to gain a better understanding of the world around them and how things work (Mbati, 2013).

Technology has been advancing exponentially over the last few decades, which has given, rise to more jobs in the technical and engineering fields. This project will utilize robotics along with other online technology, which will allow the students to collaborate and work together through a Connectivist approach that adapts the Constructivist theory to modern technology (Siemens, 2014). Robotics serves as a stepping-stone for students with interests in STEM to prepare them with the knowledge and skills needed for future

jobs. In schools now the focus is on mobile robotics, this is a field that is gaining interest and focuses on small moving robots (Demetriou, 2011). As a result allowing students to work on robotics in schools is helping to prepare them for the future.

This project was an action research project focusing on the effect of a flipped classroom setting on student engagement and learning for robotics. Observations and reflections are integral tools of action research that were used to gauge the effectiveness of the flipped instruction (Calhoun, 2002). Flipped instruction refers to the changing of traditional in class teaching to learning outside of class and applying their learning in class (Bishop and Verlerger, 2013). Students will have online modules, which will serve as homework that they need to complete prior to coming to class. The students will then use class time to work on their robots and interact and collaborate with their team. The online modules will be chunked by topic to better support student learning (Saban, 2013). There have been several studies that have combined flipped classrooms with action research, which has shown that it is an effective way of incorporating technology in the classroom (Villanueva, 2016). It has been shown that by integrating instructional design elements the content can be broken down in the online modules into sections that will help to scaffold learning (Yelamarthi, Drake and Prewett, 2016). Through the use of technology students will learn not only the content but also invaluable tools that they can apply throughout their lives. These tools are part of what robotics is teaching technical skills and a way of thinking focused on problem solving and improving (Alimisis, 2012). The goal of this project was to look at creating a learning environment around the student's needs that will engage them and help to further their interest in robotics and STEM.

Project Design & Development

Robotics Classroom

The institution that I run the robotics program for has competed in robotics competitions for more than a decade. They have participated in various robotics competitions over the years and have had varying degrees of success. Over this time we have seen and tried a variety of different things to improve and grow our robotics program. This project was designed to better maximize time and resources, allowing students to learn conveniently on their own time in order to maximize the in-class work time. This project was designed as an action research project, which would look at the effects of flipping instruction for robotics. As a result there were two major facets of this project, the online learning modules that needed to be completed prior to class and then the in-class activities. Google Classroom served as the learning management system where students can access the content and assignments for this project online.

This project was further broken down into six units that focused on various topics and sections needed for robotics. These units were designed around what the students need to know for the competition and how to build a robot. The units are aligned with the in-class activities allowing the students to learn and then directly apply that learning in the class. There are also reflections that served as the documentation for the robot and require the students to explain their thinking and rationalize their decisions. These

reflections were completed after every work period and follow the Engineering Design Process that the students are familiar with. The data in Figure 1 depicts the Engineering Design Process a problem solving process that the students used to help them plan for each unit's online modules and in class activities.

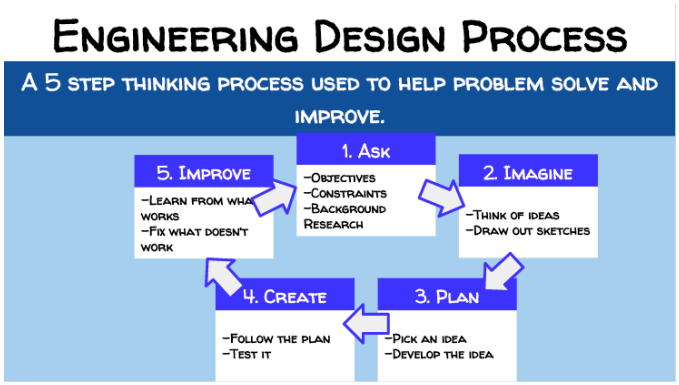

Figure 1. Engineering Design Process slide from the Online Module.

Design of the Online Modules

The online modules are comprised of Google Slides documents that have information, videos and other visuals. The modules were designed to be engaging and interesting for the students focusing on visuals over text. The students involved in this project have experience using technology and will have a MacBook Air issued by the school available to them while they are at school. The in-class activities will serve as an opportunity for the students to apply their learning and problem solve. During this time the teacher also had the opportunity to make observations and provide direct feedback to the students. There were two main research questions for this project; the first is what is the effect of the flipped instruction on the engagement of the students? The other central question is what effect would this flipped instruction have on the quality of the robot and the time needed to complete it? These questions focused on the overall flipped classroom and would be used to see if it is worth using in future years.

The robotics platform that the students used was VEX EDR and through Google Classroom students used various G-Suite apps and watched other online videos and tutorials throughout the project. VEX EDR is an international robotics competition for students in middle school and high school. To assess the effectiveness of this action research project, there were a series of assessment tools that were implemented both formally and informally. Each module and activity involved a formative assessment where students needed to answer a series of questions to verify their learning. Each component served as a milestone project that was assessed as summative assignment. I also conducted observations and informal interviews while interacting with the groups to assess their understanding and the effectiveness of the modules and activities. Throughout the entire project the students were responsible for keeping a running engineering journal or log where they needed to reflect on their learning. The reflections were also used to assess the students learning and thought process as they describe their

rationale and decisions. The data collected through this will be primarily quantitative data.

The online modules were created on Google Slides and followed a similar format to the one that is used in my regular classes. As a result the students were familiar with the layout and knew exactly what to do and what was expected of them. There were two parts of these online modules, the first being the online learning segment and the second being the reflections following the in-class activities. The online portion of this class was set up to scaffold learning and allow the students to become better prepared with a combination of online and in class learning. The online learning segments utilized a combination of videos, images and text to make it easy for the students to understand and keep their interest and engagement.

This project was developed around the different parts of the robot and various concepts that the students would need to know in order to prepare them for the designing and creating the robot. Figure 2 depicts one of the slides that were shared with the students on the online modules. The whole project was broken up into the six units and each unit consisted of the online learning module, the in-class activities and then the online reflections. To help students organize information and stay on track the Google Classroom LMS was used as seen in Figure 3 as well as reminders and instructions in class.

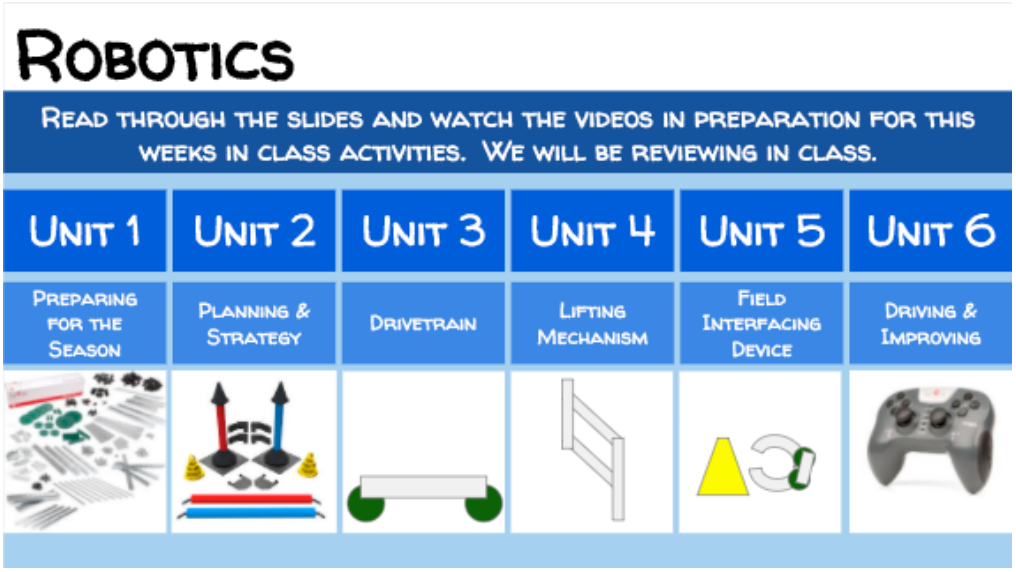

Figure 3. Slide that depicts the six units of the project.

Figure 3. Top of the Google Classroom page where students access the online modules.

The online learning modules were created to be user friendly so that middle school students could clearly see, understand, and learn from. To make learning engaging and interesting to the students the learning modules utilize a combination of videos and visuals with text that is simplified for students to understand easily. By visually seeing and learning the students had a better understanding of what they were going to be doing and how the robot would fit together. Figures 4 and 5 illustrate what the instructional slides look like with large visuals and videos.

Figure 4. Title slide of the online module for the first unit.

Figure 5. Slide of the online module that depicts the utilization of videos and visuals.

Design of the In-Class Activities

This project was designed to also utilize in class work time where students could receive direct instruction and feedback from the teacher as well as time to collaborate with their team. The online modules help with this transition of online learning and inclass activites by preparing the students with the knowledge and information that they needed for their projects. Figure 6 depicts part of this transition where the online module provides the instructions and then has the students plan and prepare for what they would be doing in class. This was a vital part of this aspect of this project so that I could ensure student learning and so that I could help them in the application of their learning.

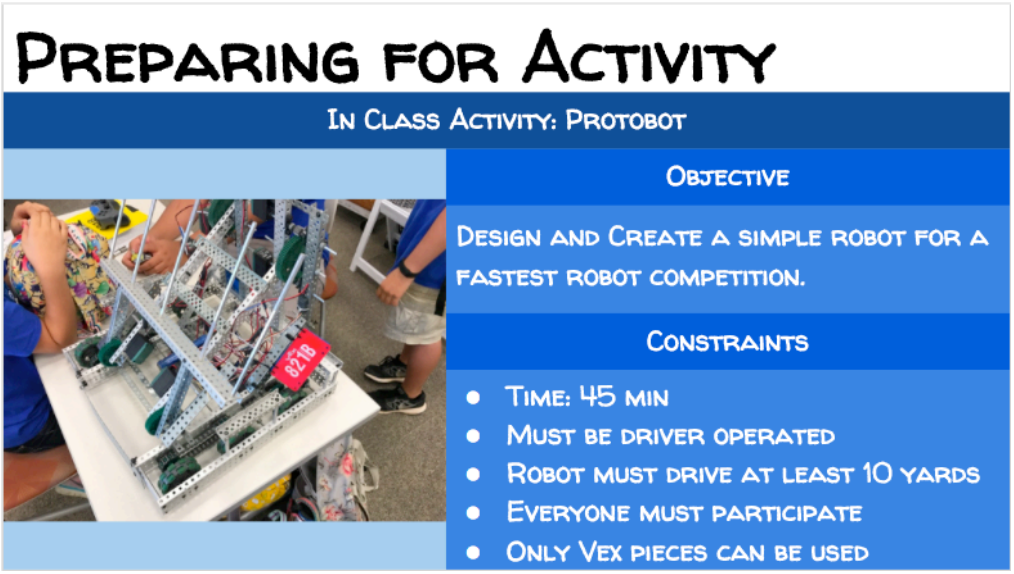

Figure 6. Slide of the online module showing instructions for the in class activities.

Design of the Assessment Tools

In order to assess the effectiveness of this project there were several tools that were used. The goal for this project was to create a flipped classroom instruction was to see the effect that it would have on the student engagement as well as the quality of the robot and time needed to complete it. As a result the tools used to assess this was classroom observations, interviews, daily reflections from the students and assessing the overall quality of the finished robot. The teacher at several points throughout each class period conducted classroom observations. To measure engagement I decided to look at the level of students being on task, collaboration and their contribution on the robot. This was done on a simple scale of one to five, one being not at all and five being completely or constantly. Along with this I went around and informally interviewed the students checking for understanding and providing feedback and guidance in order to personalize the instruction and meet their needs.

The daily reflections also served as an assessment tool were the students documented their work and needed to explain and provide examples for what they did in each class period. This provided insight into the students understanding and helps them to internalize and process what they learned in the online modules and how they applied that learning in the in class activities. This was also tied to the overall robot that was assessed by its quality compared to previous years.

Conclusion

In planning, developing, and implementing this action research project, I have learned many things about both action research and flipped classrooms. One of the things that became evident was the importance of planning and preparing beforehand. For a flipped classroom setting it is pivotal to ensure that the learning modules are clear and easy to understand. Likewise it is also important to make sure that the students have the direct face-to-face feedback and support. The combination of online learning and in class activities is a complicated balance, therefore it is necessary to assess student learning and adjust in class when needed.

It is also important to have the instructions clear and easy to understand. Student motivation and prior knowledge and skill can be helpful but like in any other teaching situation, teachers need to adjust to ensure that the students can succeed. Action research is a valuable tool as it allows us as teachers to learn along with our students and improve our teaching skills. Also, by improving our teaching in such a way we have the opportunity to really help the students learn and make meaningful improvements to our teaching in order to better address the needs of the students. Activities such as this make learning more engaging and interesting for the students, which in turn helps to make learning more fun for them. Overall action research such as this can be used as a win-win situation for both the students and teachers and can encourage us to always further ourselves as life long learners.

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